No. 10.—*Upper Jurassic and Lower Cretaceous Ammonites of the Malone Mountains, Trans-Pecos Texas*

By Claude C. Albritton, Jr.

INTRODUCTION

The Malone Mountains are located in southern Hudspeth County, Texas, and may be found on the Fort Hancock topographic sheet. Since 1890 the marine invertebrate fauna enclosed in the Mesozoic rocks of this small desert range and its satellite hills has attracted the attention of paleontologists and collectors. To date the most comprehensive account of the paleontology is that of F. W. Cragin (1905, pp. 34–109, Pls. I–XXIX)[1], who has described many new species from the area. Most of Cragin's specimens were collected about a mile northeast of the Malone Mountains from low, outlying hills known as the Malone Hills.

Cragin believed that the entire sedimentary sequence of the Malone Hills and Mountains was of Jurassic age. Accordingly, he named this sequence the Malone formation, correlating it, on the evidence of ammonites, with the Tithonian of Europe. More recently, however, F. L. Kitchin (1926) has suggested that a part of Cragin's Malone formation is of Lower Cretaceous age, and C. L. Baker (1927, p. 11) has cited evidence for the presence of Permian strata in the area.

In an attempt to solve the stratigraphical problems of the area, the writer in the summers of 1934 and 1935 made an intensive study of 63 square miles centering around the Malone Hills and Malone Mountains. This survey was supervised by Professor M. P. Billings of Harvard University, and conducted with the able assistance of Messrs. C. C. Albritton, Sr., J. Fred Smith, Jr., and J. D. Boon, Jr. Fossils were collected from some 25 carefully measured sections, so that for the first time it is possible to refer individual species to their precise horizons and thus determine the geological ages of the several formations in the area.

The writer's collection includes more than a hundred specimens of ammonites. Careful study of these, under the direction of Professor P. E. Raymond, has shown that thirteen species are represented. Of these, five are new and four have not been previously reported from the area. The abundant material at hand has, in addition, provided significant new data on previously described species. Accordingly, the writer presents in the following paragraphs a complete account of the ammonites. Where taxonomic revision has been necessary, he has been guided by the published comments of Burckhardt, Spath, Uhlig, and Adkins, acknowledged in the descriptive portions.

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[1] Numbers in parenthesis refer to papers listed in the bibliography.

Since there is at present no accurate published account of the stratigraphy of the area, it is necessary to include the following generalized section, to which the fossils may be referred.

General Stratigraphical Section of Malone Mountains and Outlying Hills

Quaternary and Tertiary	Thickness in feet
Basin-fill (sand, clay, and gravel)	0–100+
Unconformity	
Lower Cretaceous	
Glen Rose formation — thin-bedded, impure limestone with interbedded sandstone and grit	750+
(Unexposed)	1500
Las Vigas (?) formation — red, sandy shale, impure limestone, and limestone-pebble conglomerate	50+
(Unexposed)	500
Torcer formation (emended) — impure limestone, sandstone, and sandy shale, with basal quartzitic sandstone and chert-pebble conglomerate	400+
Upper Jurassic	
Malone formation (emended)	
Upper Division — black limestone with local sandy beds toward top	150–330
Lower Division — thin-bedded sandstone, sandy shale, impure limestone, and limestone conglomerate	0–685
Unconformity	
Permian	
Briggs formation — gypsum with interbedded limestone	630+

DESCRIPTIONS OF SPECIES

Family HAPLOCERATIDAE Zittel

Genus HAPLOCERAS Zittel

HAPLOCERAS CRAGINI spec. nov.

Plate I, figs. 3, 4; Plate V, figs. 1–4

Oppelia (?) *fallax* (Cragin) not Castillo and Aguilera, U. S. Geol. Survey Bull. 266, 1905, pp. 101–102, Pl. XXII figs. 2, 3.

Specific Characters. Coiling oligogyral, serpental; subangustumbilicate. Sides convergent, feebly to moderately convex; venter arched. Whorls compressed. Umbilical wall high in variety with relatively depressed whorl-section, low in variety with relatively compressed whorl-section; rounded in both instances.

Shell smooth, with faint flexuous striae arising at the planispiral suture, inclined slightly backward as they traverse the umbilical slope, above which they are deflected slightly forward. Most of the striae disappear before reaching the venter. Striae entirely lacking in some specimens; apparently this is more often the case in the relatively depressed than in the relatively compressed variety.

Suture lines complex, interlocking, with large unsymmetrical, trifid, first lateral lobe the dominant element.

Measurements.[1]

Variety a. (Whorl-section relatively compressed)

A.	140	42%	25%	22%
B.	117	38%	23%	20%
C.	130	43%	30%	23%
D.	80	44%	31%	21%
E.	115	40%	31%	23%
F.	182	38%	27%	23%

Variety b. (Whorl-section relatively depressed)

G.	90	46%	35%	21%
H.	134	42%	36%	25% (?)
I.	42	50%	35%	15% plus

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[1] All measurements are cited in the conventional order, from left to right: (1) Diameter in mm. (2) Height of outer whorl as % of diameter (3) Thickness of outer whorl as % of diameter, and (4) width of umbilicus as % of diameter.

Observations. Two varieties, distinguished only by relative compression of whorl-section, were found associated wherever this species was collected.

Cragin (1905, pp. 101–102, Pl. XXII, figs. 2, 3) has described the young stage of variety b. This he referred to *Placenticeras fallax* Castillo and Aguilera, reassigning the species to the genus *Oppelia* (?).

Consideration of several excellent specimens at hand shows that the Malone species differs from *Placenticeras fallax* as described by Castillo and Aguilera (1895, p. 17, Pl. VIII, figs. 1, 2) in wider umbilicus and presence of striae on the later whorls. Moreover, the Malone species lacks the angulation at the margin of the umbilical slope, a feature which is not mentioned in the verbal description of Castillo and Aguilera, but which is readily apparent in the figures.

In generic assignation of this species Cragin wavered between *Oppelia* and *Haploceras:*—

"As it makes some departures from the characters belonging to most of its congeners, this ammonite may seem at first sight almost as much of an anomaly in the genus *Oppelia* as it was supposed to be in *Placenticeras.* But the suture, which has the lobes and saddles very few instead of many, and has the first lateral lobe contrastingly the largest, sufficiently distinguishes it from the latter genus and relates it to *Oppelia* and *Haploceras,* with which also agree its . . . compressed lenticular form, and the absence of periodical constrictions. It seems indeed to have its closest affinities and to belong among the round-ventered, phylogerontic forms of *Oppelia* which occur in the latest Jurassic rocks, in which this genus makes its final appearance; the venter, in *O. fallax,* being rounded both on the outer and on the inner whorls." (Cragin, 1905, p. 102.)

Indeed the difficulty in distinguishing between *Oppelia* and *Haploceras* first arose in the mind of Zittel, who in founding the latter genus observed that the length of living chamber, large siphonal sheath, and suture pattern were confusingly similar in the two genera. (Zittel, 1870, pp. 48–49.)

Among the more important distinguishing characteristics, however, Zittel emphasized the unornamented, laevigate or finely striate shell of *Haploceras,* and it is largely on this basis that the Malone species is here referred to *Haploceras* rather than *Oppelia.*

Insofar as the writer is aware, *Haploceras cragini* is not likely to be confused with any previously described species. It may be distinguished from *H. fialae* Oppel by the absence of a spiral furrow. From *H. transatlanticum* Burckhardt, *H. zacatecanum* Burckhardt, *H. mexicanum* Burckhardt, *H. costatum* Burckhardt, and *H. ordonezi* Aguilera, all from the Jurassic of Mexico, *H. cragini* may be distinguished by the convergence of the lateral areas and the weakness of the striae. The more compressed whorl-section and more narrowly rounded venter serve to separate the Malone species from *H. staszycii* Zeuschner, *H. elimatum* Oppel, *H. indicum* Uhlig, and *H. verruciferum* Meneghini. The smooth, uncrenulated venter of the Texas species differentiates it from *H. tomephorum* Zittel, *H. rhinotomum* Zittel, and *H. carachtheis* var. *subtilior* Zittel. From *H. rasile* Zittel, *H. cragini* is readily distinguished by the convergence of the lateral areas.

H. cragini is restricted to the lower division of the Malone formation. Fragmentary specimens are abundant at the southeastern end of the Malone Hills, and more complete ones may be collected along the southwestern side of the Malone Mountains. Holotype (M. C. Z. 3861) from Ammonite Canyon, Malone Mountains.

Family STEPHANOCERATIDAE Neumayr emend. Zittel

Genus IDOCERAS Burckhardt

IDOCERAS SCHUCHERTI (Cragin)

Plate II, fig. 1, Plate V, figs. 6, 7

Perisphinctes schucherti Cragin, U. S. Geol. Surv. Bull. 266, 1905, pp. 107–108, Pl. XXV, fig. 1, XXVI, figs. 1–3, XXVII, fig. 1.

Specific Characters. Coiling polygyral, serpental, subangustumbilicate. Sides plano-convex, whorl-section compressed; venter arched, with tendency to become slightly tabulate in some specimens. Subgradumbilicate.

Early whorls (at least first five) with closely-set costae bifurcating or trifurcating at about the middle of the flanks into feebly divergent smaller branches inclined slightly forward.

Costation greatly reduced with increase in size of shell, disappearing first from the middle of the flanks, then from the umbilical slopes, and finally, in at least one specimen, from the ventral region. Most specimens, however, maintain weak ribbing in the ventral area, where the ends of the costae are interrupted by a smooth band. Costae with alternate arrangement on opposite sides of venter. Constrictions large, shallow, at remote intervals.

Suture lines fairly complex with broad siphonal and dominant first lateral lobe. Lateral lobes trifid, regularly decreasing from second lateral lobe toward the planispiral suture.

Measurements.

A.	135	40%	20%	28%
B.	147	36%	18%	33%
C.	168	40%	19%	24%

Observations. Burckhardt has compared *Idoceras schucherti* with two closely related forms from the Kimmeridgian of San Pedro del Gallo: *I. lorioli* Burckhardt and *I. cragini* Burckhardt. With reference to *I. lorioli* Burckhardt has written:

"A closely related species appears to be *Perisphinctes schucherti* Cragin *pro parte* (Cragin, l.c. p. 107, Pl. XXV, fig. 1, Pl. XXVI, fig. 1). The Texas species may be distinguished from the Mexican form by its thicker whorls and broader umbilicus. It hardly need be said that the Malone species has absolutely nothing in common with either *Perisphinctes inconditus* Font. or *Olcostephanus potosinus* Castillo and Aguilera, forms with which Cragin sought to ally his species." (Burckhardt, 1912, p. 111 — translation.)

Burckhardt could detect no appreciable differences between the specimen of *Idoceras schucherti* figured on Plate XXVII of Cragin's bulletin and *Idoceras cragini*, but refrained from referring his Mexican form to Cragin's species because of the inadequacy of the latter's figures and descriptions. (Burckhardt, 1912, pp. 119–120.)

Specimens of *Idoceras schucherti* in the writer's collection clearly exhibit the close relationship of this species to *I. cragini*, as suggested by Burckhardt. The dimensions of the Texas and Mexican forms differ by negligible percentages (2% to 5%), and the suture patterns are strikingly similar. On the other hand, the writer believes that the two forms should be maintained as distinct species for the following reasons.

1. *Idoceras schucherti* exhibits a more pronounced tendency toward complete reduction of ornamentation with increasing size than does *I. cragini*.

2. The length of the second lateral lobe of *I. cragini* more nearly approaches that of the first lateral lobe than is the case in the Malone species.

3. The third and succeeding lateral lobes of *I. cragini* are more strongly inflected toward the first lateral lobes than are those of *I. schucherti*.

Idoceras schucherti (Cragin) is restricted to the lower division of the Malone formation, in which it is comparatively rare. Plesiotype (M. C. Z. 3863) from Ammonite Canyon, Malone Mountains.

Idoceras clarki (Cragin)

Plate III, fig. 1, Plate V, figs. 5, 8, 9

Perisphinctes clarki Cragin, U. S. Geol. Surv. Bull. 266, 1905, pp. 103–105, Pl. XXIX, figs. 1, 2.

Specific Characters. Coiling polygyral, serpental, subangustumbilicate to sublatumbilicate. Whorls compressed; sides feebly to moderately convex; venter arched. Subgradumbilicate.

First several whorls (7 to 9) with sharp, closely set, anteriorly inclined costae arising at the planispiral suture, bifurcating or trifurcating slightly above mid-points of sides, and interrupted along the venter by a narrow, smooth band. Branches with alternate arrangement at venter. Occasional narrow constrictions bounded on one side by unbranched ribs parallel the costae. Ornamentation gradually disappears with age; living chamber smooth or traversed by a few broad undulations.

Suture-lines fairly complex. Broad-trunked siphonal lobe indented by broad, weakly-indented, trifid, median saddle. Lateral lobes narrow, trifid. First lateral lobe the major sutural element: about twice the length of second lateral lobe.

Measurements.

A.	188	37%	21%	33%
B.	83	33%	21%	40%
C.	235	33%	19%	40%
D.	265	33%	19%	39%

Observations. In his discussion of this species Cragin (1905, p. 105) makes the following observations:

"It is not unlikely that this is the same species as that figured and briefly described from the Tithonian of Mexico as "*Perisphinctes*" sp. (?) by Castillo and Aguilera, and compared by them in its ribbing with *P. lictor*, *P. haliarchus*, and *P. polygyratus*. The septal line bears considerable resemblance to that of the latter species, which, from the White Jura Beta, Quenstedt figures under the name of "*Ammonites triplicatus albus*.""

In the writer's opinion, however, the description and figure of the Tithonian fragment are insufficient for adequate comparison. (See Castillo and Aguilera, 1895, p. 35, Pl. XIX.)

Moreover, although the sutures of "*Ammonites triplicatus albus*" are broadly similar to those of *Idoceras clarki*, Quenstedt's species does not show the notable diminution in costation with increase in size exhibited by the Malone species. (See Quenstedt, 1888, Pl. 100, fig. 8.

On the other hand, *Idoceras clarki* appears to be closely related to *I. durangense* Burckhardt from the Kimmeridgian of San Pedro del Gallo (Burckhardt, 1912, p. 107, Pl. XXVI). The dimensions of the two species differ within small percentages, the suture-lines are practically identical, and both forms exhibit a strong tendency toward complete loss of ornamentation with increase in size. *Idoceras durangense*, however, retains weak ventral costae in the more advanced stages of growth, whereas even this feeble ornamentation is lost at comparable stages of the Malone species.

Idoceras clarki is restricted to the lower division of the Malone formation, in which it is comparatively abundant. Plesiotype (M. C. Z. 3864) from Ammonite Canyon, Malone Mountains.

Genus LITHACOCERAS Hyatt

LITHACOCERAS MALONIANUM (Cragin)

Plate I, fig. 2, Pl. II, fig. 2, Plate VI, figs. 1–3

Olcostephanus malonianum Cragin, U. S. Geol. Survey Bull. 266, 1905, p. 103, Pl. XXIV, figs. 1, 2.

Perisphinctes potosinus Cragin (not Castillo and Aguilera) ibid., pp. 105–106, Pl. XXIII, fig. 1.

Perisphinctes felixi Cragin (not Castillo and Aguilera) ibid., pp. 106–107, Pl. XXIII, fig. 2.

Specific Characters. Coiling polygyral, serpental, sublatumbilicate. Whorl-section depressed in young stages, becoming less so with increase in size; slightly compressed in later whorls. Sides faintly to moderately convex; venter broadly rounded. Subgradumbilicate.

Sides with closely set, sharply defined costae arising at the planispiral suture, traversing the flanks inclined slightly forward, and branching near the middle of the sides into feebly divergent ribs which cross the venter uninterruptedly, at least in the septate portions of the shell. Costae of the first four to six whorls close-set, dominantly bifurcating, occasionally simple, trifurcating, or intercalated. Succeeding whorls with progressively larger and more widely spaced primary costae, with a correspondingly greater number of ventral branches per lateral costation. Largest whorl-fragment observed (height 90 mm.; breadth 85 mm. — septate portion of shell) with at least four and possibly more ventral branches per lateral costation. Somewhat smaller whorls bear dominantly trifurcating ribs. Constrictions shallow and widely spaced.

Suture-lines complex. Siphonal lobe the dominant element in early stages (at least in second and third whorls), later surpassed in length by the first lateral lobe, which is extremely broad-trunked in comparison with succeeding lobes. Lateral lobes trifid; external saddles bifid, narrowly constricted near their bases by branches of the adjacent lobes.

Measurements.

A. 165 . 25% . 34% . 46%
B. 125 . 24% . 37% . 47%

Observations. Consideration of the large suite of specimens at hand shows that the forms designated by Cragin as *Perisphinctes felixi P. potosinus,* and *Olcostephanus malonianus* represent successive growth stages of a single species of *Lithacoceras.* It is hardly necessary, therefore, to compare the Malone species with the Mexican forms to which Cragin supposed it was allied.

In the younger stages, the shells of *Lithacoceras malonianum* (with bifurcating costae) are indistinguishable from those of the Kimmeridgian form designated as *Perisphinctes mclachlani* by Burckhardt (1906, pp. 24–25, Pl. IV, figs. 407). The Mexican species was defined on the basis of a single internal cast with the following measurements: 60 . 30% . 35% . 51%. At comparable stages of development the sutures of the Texan and Mexican forms are identical, insofar as can be judged from Burckhardt's tracings. As has been noted, however, the adult suture of *Lithacoceras malonianum* exhibits considerable modifications of the early suture pattern — the first lateral lobes become longer than the siphonal lobe, and the saddles become greatly constricted at their bases.

Burckhardt notes a weakening or notching of the costae as they cross the venter. This is likewise characteristic of the internal casts of *Lithacoceras malonianum,* but wherever the shell is preserved, the ribs are seen to traverse the siphonal area without any weakening whatsoever. (See in this connection Cragin, 1905, Pl. XXIV, figs. 1, 2.)

These facts indicate a close relationship between the two forms in question; indeed the evidence cited favors the hypothesis that *Perisphinctes mclachlani* Burckhardt in an immature specimen of *Lithacoceras malonianum* (Cragin).

Lithacoceras malonianum is restricted to the lower division of the Malone formation. It is fairly abundant near the top of this division. Plesiotypes (M. C. Z. 3865, 3866) from Ammonite Canyon, Malone Mountains.

LITHACOCERAS SHULERI spec. nov.

Pl. III, fig. 2; Pl. VII, figs. 1, 2, 4

Specific Characters. Coiling polygyral, serpental, sublatumbilicate (?). Whorls compressed, markedly so in young stages; largest whorl-fragment at hand almost equidimensional. Subgradumbilicate. Venter narrowly rounded to fastigate.

Early whorls with pronounced, narrowly rounded costae arising at the planispiral suture and traversing the sides inclined slightly forward, remaining single or parting into two narrowly divergent branches which are opposed on opposite sides of the sharpened venter. With increase in size the lateral costae become more pronounced and more widely spaced. The ventral costae, however, remain closely and regularly spaced, two to four of them corresponding to a single lateral rib. With still further increase in size, the ventral costae disappear, and the lateral ones assume the form of prominent bullae. Living chamber unknown.

Suture lines complex, with narrow, trifid, first lateral lobes the dominant elements. These are, however, only a little longer than the siphonal lobe. External saddles bifid, narrowly constricted by branches of the adjacent lobes.

Measurements. No complete specimens were collected. The dimensions of several whorl-fragments are given below.

	Height	Breadth
A.	27 mm.	22 mm.
B.	90 mm.	86 mm.
C.	67 mm.	73 mm.

Observations. Lithacoceras shuleri appears to be more closely related to *L. malonianum* (Cragin) than any other species the writer has found cited in the literature: this despite the marked differences in whorl-section, the more prominent lateral costation, and more rapid loss of ventral costae in *L. shuleri*. The sutures of the two species are almost identical; indeed they cannot be distinguished except perhaps by the more complete strangulation of the external saddles of *L. shuleri* by branches of the external and first lateral lobes.

Lithacoceras shuleri is restricted to the lower division of the Malone formation, in which it is rare. The holotype (M. C. Z. 3867) was collected at Ammonite Canyon in the Malone Mountains.

Genus KOSSMATIA Uhlig

KOSSMATIA AGUILERAI (Cragin)

Plate VIII, figs. 2, 6

Perisphinctes aguilerai Cragin, U. S. Geol. Surv. Bull. 266, 1905, p. 105, Pl. XXVIII, figs. 1, 2.

Specific Characters. Coiling polygyral, serpental. Whorls compressed, with feebly convex flanks and arched venter. Subgradumbilicate.

Flanks traversed by prominent, round-topped costae, which arise at the planispiral suture, ascend the umbilical wall inclined slightly backward, and traverse the flanks in the form of shallow, anteriorly-convex arches which bifurcate above the middle of the flanks. Secondary costae of opposite sides meet on the periphery approximately at right angles. Costae slightly elevated at loci of bifurcation.

Suture lines moderately complex; patterns unknown.

Measurements. (known only from whorl-fragments)

	Height	Breadth	B/H%
A. (Cragin)	107 mm.	84 mm.	79%
B. (Cragin)	57 mm.	50 mm.	87%
C.	54 mm.	41 mm.	75%
D.	45 mm.	34 mm.	75%

Observations. In his review of Cragin's bulletin, Uhlig noted that this species appeared to belong to the group of *Perisphinctes richteri* Oppel, a widely-distributed east-Indian and European group of Tithonian age, one which he had previously assigned to the genus *Kossmatia*. (Uhlig, 1910, pp. 267–268; 1907, pp. 285–286.)

Judging from a comparison of Cragin's figures and descriptions, Spath agreed with Uhlig in the assignment of the Malone species to *Kossmatia* (Kitchin, 1926, pp. 254 ff.). The writer can find no features in the specimens at hand which negative this diagnosis.

Owing to the extremely fragmentary condition of the specimens in the writer's collection and those previously described by Cragin, the following comparisons are necessarily incomplete and liable to error.

From *Kossmatia pectinata* Burckhardt and *K. interrupta* Burckhardt, the Malone species may be distinguished by its more broadly rounded venter. (Burckhardt, 1912, pp. 135–136, Pl. XXXIV, figs. 1, 7–10, 14; pp. 134–135, Pl. XXXIV, figs. 2–3, 15.)

The ventral costae of *K. aguilerai* are inflected more strongly forward than are those of *K. burckarti* (Burckhardt, 1906, p. 133, Pl. XXXVII, figs. 2, 10).

From *K. santarosanus* Burckhardt the Malone species may be distinguished by its broader venter and less flexuous lateral costae. (Burckhardt, 1906, p. 129, Pl. XXXV, fig. 104.)

K. aguilerai appears to be closely related to *K. victoris* Burckhardt from the upper Portlandian of Mazapil. There is a tendency, however, for the lateral costae to become more broadly spaced with increase in size in *K. aguilerai* than in the Mexican form. (Burckhardt, 1906, p. 131, Pl. XXXVI.)

At least with respect to ornamentation *K. aguilerai* is closely related to *K. flexicostatus* Castillo and Aguilera, although comparison with this and other of the Catorzan species is hindered by the inadequate illustrations of the latter. (Castillo and Aguilera, 1895.)

Kossmatia aguilerai is restricted to the upper division of the Malone formation. Plesiotypes (M. C. Z. 3875 and 3876) from southwestern side of Malone Mountains near Cedar Canyon.

KOSSMATIA ZACATECANA Burckhardt

Plate VII, fig. 3

Kossmatia zacatecana Burckhardt, Bol. del Inst. Geol. de México, No. 29, 1912, pp. 136–138, Pl. XXXIV, figs. 4, 5, 6, 11, 12, 13, 16, 17, 20.

Specific Characters. Following is a translation of Burckhardt's original description, to which the Malone specimens appear to conform in every essential detail.

"The internal whorls are similar, both in form and ornamentation, to certain *Reineckia*. The test is somewhat thick, composed of slightly embracing whorls. The sides are narrow but the ventral area is unusually broad and feebly convex. The whorl section is depressed. The sides are covered with strong, linear, slightly oblique costae. They are uncrowded, and give rise about the middle of the flanks to two or three much less prominent secondary costae. At the points of branching the primary costae are elevated to form narrow lamelliform prominences or tubercles. There are occasional intercalated secondary costae and simple primary costae. The ventral costae are inclined slightly forward, those of opposite sides forming large angles with apices at the siphonal line, where the costae are considerably weakened but not completely effaced.

The larger whorls of our specimens show notable differences when compared with the previous ones. The general form, it is true, is still depressed. But the ornamentation now consists of strong and widely spaced primary costae inclined obliquely forward and bifurcating about the middle of the flanks into secondary costae likewise inclined anteriorly.

Where there are three secondary branches, the division is almost always virgatotomous. The secondary costae are more clearly directed forward than is the case in the younger whorls, and are more clearly depressed in the siphonal tract.

The constrictions are not prominent.

External lobe not very broad, a little deeper than the first lateral lobe. The latter is thin and symmetrical with three principal branches. The second lateral lobe is small, slightly oblique, and trifid. It forms a weakly developed sutural lobe with two or three pointed auxiliaries. External saddle broad, divided at its summit into two unequal branches, of which the external one is the larger. First lateral saddle narrow, divided by a secondary lobe directed obliquely forward into two unequal parts of which the external one is the higher. Second lateral saddle low and small, trifid at its summit.

The species is closely related to *K. pectinata*. It is distinguished by its broader whorls, more narrow umbilicus, by the greater number of tripartate costae, and finally by the slighter inflection of the costae."

Measurements.

A. Original of Burckhardt........25 . 38% . 54% . 48%

B. Malone specimen — not reliable owing to distortion of fragmentary test.

Observations. The specimen at hand agrees with the above description in every observable particular with the exception that the larger whorls are slightly compressed rather than depressed. Burckhardt's specimens, however, do not show this advanced stage of development, so that the change from depressed to compressed whorl-section is probably to be attributed to normal ontogenetic development of the Mexican species.

The holotype is from the Upper Portlandian near Casa Sotelo, Santa Rosa, Mazapil, Mexico. In the Malone area the species is restricted to the upper few feet of the upper division of the Malone formation. Plesiotype (M. C. Z. 3877) from west bank of Iris Canyon, Malone Mountains.

Family ASPIDOCERATIDAE Zittel

Subfamily ASPIDOCERATINAE Zittel emend. Spath

Genus PHYSODOCERAS Hyatt

PHYSODOCERAS SMITHI spec. nov.

Plate I, fig. 1, Plate VIII, figs. 1, 3

Aspidoceras alamitocensis Cragin (not Castillo and Aguilera), U. S. Geol. Survey Bull. 266, 1905, p. 109, Pl. XXVII, fig. 2.

Specific Characters. Coiling oligogyral, serpental, subangustumbilicate. Whorls inflated, sides convex. Whorls depressed with arched venters. Subgradumbilicate.

Shell densiflexistriate; unituberculate, with row of nodes or bullae surrounding the umbilical margin (13 on outer whorl of specimen figured). Tubercles closely and regularly spaced on earlier whorls, with tendency to become irregularly spaced on later whorls. Low, poorly defined undulations rising at and between the tubercles of the outer whorl cross the venter uninterruptedly.

Suture lines moderately complex with regularly decreasing bifid saddles.

Measurements.

A.	(Holotype)	105 mm.	. 42%	. 57%	. 29.5%
B.		140 mm.	. 40%	. 49.5%	. 30%

Observations. Cragin (1905, p. 109, Pl. XXVII, fig. 2) has referred a fragmentary specimen of this species to *Aspidoceras alamitocensis* Castillo and Aguilera. As compared with the Mexican species, however, *P. smithi* has a single rather than a double row of tubercles, is more narrowly umbilicate, and has a considerably more depressed whorl-section.

The relatively depressed whorl-section, strong development of the inner series of tubercles, broad, slightly-dissected saddles, and large size of shell are sufficient to distinguish the species from any of the closely related unituberculate Kimmeridgian species of the Mexican Jurassic.

P. smithi is restricted to the lower division of the Malone formation. It is comparatively abundant at Ammonite Canyon, where the holotype (M. C. Z. 3869) was collected.

PHYSODOCERAS BOONI spec. nov.

Plate IV, fig. 2

Specific Characters. Coiling oligogyral, serpental, subangustumbilicate. Whorls depressed with arched venter. Subgradumbilicate.

Shell densiflexistriate; unituberculate, with row of conspicuous nodes encircling the umbilical border. Venter of outer whorl crossed by a few, poorly-defined, irregular, undulations.

Sutures fairly complex with comparatively narrow bifid saddles decreasing in size with apparent regularity away from the venter.

Measurements. 90 mm. . 50% . 64% . 28%

Observations. *Physodoceras booni* appears to be rather closely related to *Aspidoceras contemporaneum* Favre, as described by Burckhardt (1906, pp. 32–34, Pl. V, fig. 104) from the zone of *Idoceras* at Mazapil. From this species, however, *P. booni* may be distinguished by its more depressed whorls and fewer, larger nodes.

The new species may be distinguished from the superficially similar Kimmeridgian species, *Aspidoceras psuedomicroplum* Burckhardt and *A. pavlowi* Burckhardt by its more depressed whorls and total lack of outer series of nodes. (Burckhardt, 1912, pp. 78–81, Pl. XIX, figs. 1–10.)

From *Physodoceras smithi*, *P. booni* is readily distinguished by its fewer, larger tubercles, and more depressed whorl-section.

P. booni closely resembles Favre's figures of *Ammonites liparus* Oppel, apparently differing from this species only in its more depressed whorls and in minor details of what little of the sutures is figured (Favre, 1875, pp. 46–47, Pl. figs. 4a–b). Oppel's figure of the same species, however, shows further and more pronounced differences in the presence of spines in the case of *A. liparus* as opposed to nodes in the case of the Malone species (Oppel, 1862, p. 22, Pl. 59, fig. 1). Considered collectively, therefore, the differences in whorl-section, ornamentation, and sutures are sufficient to warrant specific separation of *A. liparus* and *P. booni*, although the two forms are certainly very closely allied.

Physodoceras booni is restricted to the lower division of the Malone formation, in which it is fairly common. The holotype (M. C. Z. 3871) was collected at Ammonite Canyon in the Malone Mountains.

Physodoceras bakeri spec. nov.

Plate VIII, fig. 4

Specific Characters. Coiling oligogyral, serpental, subangustumbilicate. Whorls depressed, venter arched, sides convex. Umbilicus deep; umbilical wall almost vertical with narrowly rounded margin. Shell laevigate. Unituberculate, with row of prominent nodes encircling the umbilical margin. Nodes grow more prominent, spinose, and radially elongate with increase in size of whorl. External row of nodes lacking on all, including the earliest (second) whorl examined.

Sutures fairly complex; saddles broad, bifid, with rounded terminations.

Measurements. 43 mm. . 48% . 90% . 25%

Observations. *Physodoceras bakeri* is readily distinguished from associated Malone species by its smaller size, relatively broader whorls, and deeper, narrower umbilicus.

In breadth of whorl, general size, and umbilication *P. bakeri* presents certain analogies to *Aspidoceras cyclotum* Steuer, described by Burckhardt from the Lower Portlandian of Mazapil (1906, p. 119, Pl. XXXII, figs. 3–6). From this and associated lower Portlandian species of Mexico, *P. bakeri* is distinguished by the presence of tubercles.

The tuberculation recalls that of *Aspidoceras contemporaneum* Favre described by Burckhardt (1906, p. 32, Pl. V, figs. 1–4) from the Kimmeridgian of Mazapil. The Mexican species, however, has more compressed whorls and smaller tubercles.

With regard to ornamentation, *P. bakeri* appears to stand about midway between *Aspidoceras avellanoides* Uhlig and *A. liparus* Oppel, the nodes of the Malone species being much larger and more closely spaced than those of the former, and less conspicuous than the spines of the latter (Uhlig, 1903, pp. 75–76, Pl. III, figs. 1a–e; Oppel, 1863, p. 220, Pl. LIX, fig. 1). *P. bakeri* differs from both the above species in its more depressed whorl-section.

P. bakeri is restricted to the lower division of the Malone formation, in which it is rare. The holotype (M. C. Z. 3870) was collected southeast of Gypsum Switch in the Malone Mountains.

Genus ASPIDOCERAS Zittel

ASPIDOCERAS cf. LAEVIGATUM Burckhardt

Plate VIII, fig. 5

Aspidoceras laevigatum Burckhardt, Bol. del Inst. Geol. de México, No. 29, 1912, pp. 81–82, Pl. XX, figs. 2, 4, 9.

Included in the writer's collection are fragments of robust, smooth-shelled ammonites which (judging by their form and what little can be observed of the sutures) are referable to *Aspidoceras laevigatum* Burckhardt from the Kimmeridgian of San Pedro del Gallo.

The fragments show no nodes, only broad undulations, on the outer whorls. Inner whorls show almost imperceptible, rather closely-spaced undulations crossing the venter. Unfortunately, the dorsal and lateral portions of the inner whorls have not been preserved, so that the nature of the tuberculation, if present, cannot be stated.

Measurements. (approximate)

168 mm.	34.5%	33%	30%

In the Malone area the species is limited to the lower division of the Malone formation, in which it is rare. Plesiotype (M. C. Z. 3872) from Rust Hill, southeastern end of the Malone Mountains.

Subfamily SIMOCERATINAE Spath

Genus NEOBRITES Burckhardt

NEOBRITES NODOCOSTATUS Burckhardt

Plate IX, fig. 1

Neobrites nodocostatus Burckhardt, Bol. del Inst. Geol. de México, No. 29, 1912, pp. 98–99, Pl. XXIII, figs. 1–5.

This species is represented in the writer's collection only by large whorl-fragments showing no deviation in form, ornamentation, and suture-pattern from the Mexican species, as defined by Burckhardt.

The largest whorl at hand has a height of 68 mm. and a breadth of 71 mm. Prominent costae, becoming more inflated and tubercle-like with increase in size, rise at the planispiral suture and traverse the flanks inclined slightly forward, disappearing at the angulations which mark the edges of the smooth, gently-arched venter.

The inner whorls tend to be more compressed. They are traversed laterally by well defined costae which branch above the midpoints of the flanks. The Malone specimens are too fragmentary to disclose the nature of this branching and the disposition of secondary costae on the ventral region.

The entire suture pattern cannot be observed on any single specimen at hand, but the various elements pieced together from several fragments appear to agree with Burckhardt's tracings.

In Mexico the species is restricted to the Kimmeridgian. The holotype is from San Pedro del Gallo. In the Malone Mountains *Neobrites nodocostatus* is restricted to the lower division of the Malone formation. Plesiotype (M. C. Z. 3873) as collected at Ammonite Canyon.

NEOBRITES cf. NODOCOSTATUS Burckhardt

Plate IX, fig. 3

Neobrites nodocostatus Burckhardt, Bol. del Inst. Geol. de México, 1912, No. 29, pp. 98–99, Pl. XXIII, figs. 1–5.

A single whorl-fragment with a height of 40 mm. and breadth of 54 mm. bearing the strong lateral ribbing characteristic of *Neobrites nodocostatus* appears to differ from that species in its broader and flatter ventral area. Sutures are lacking, and the discrepancy noted may be a result of weathering. The fragment (M. C. Z. 3874) was collected from the lower division of the Malone formation at Apple Pass in the Malone Mountains.

Family COSMOCERATIDAE Zittel

Genus HOPLITES Neumayr

Subgenus NEOCOMITES Uhlig

NEOCOMITES cf. INDICUS Uhlig

Plate IV, fig. 1; Plate IX, fig. 2

Neocomites indicus Uhlig, Mem. Geol. Survey India, Palaeontologia Indica, Ser. XV, **4**, Fasc. 2, 1910, pp. 262–263, Pl. LXXXIX, figs. 4a–c.

Included in the writer's collection from the basal sandstone and conglomerate of the Torcer formation is a fragmentary whorl, the form and ornamentation of which ally it with the group of *Neocomites theodorii,* more specifically with *N. indicus* Uhlig, a Valanginian species from India.

The whorl-section is compressed, with sharpened venter and feebly convex sides merging imperceptibly with the rounded margin of the umbilical wall, which becomes steepened almost to the vertical at the planispiral suture.

Arising at the umbilical suture are conspicuous, closely spaced, sharp costae, which are inflected backward along the umbilical wall, but bend forward at the upper limit of the wall, traversing the flanks in the form of shallow, posteriorly-convex arches. Although the disposition of the lateral costae cannot be completely observed in our specimen, many of the ribs may be observed to divide about the midpoint of the flanks into feebly divergent branches inflected strongly forward in the ventral region, where opposed costations meet in obtuse angles. Other costae remain simple, but whether or not there is systematic alternation of simple and branched ribs is not known. The ribbing appears to be continuous across the venter.

The suture pattern cannot be observed in our specimen. The whorl-section has a height of 31 mm. and a width of 17 mm.

From the type figures of *Neocomites indicus* the Malone form differs in more compressed whorl-section, more closely-spaced costae, and, from some of Uhlig's specimens, by the absence of a ventral furrow. The Indian form, however, appears to be highly variable, and the differences noted are probably not specific.

In density of costation our specimen recalls Burckhardt's *N. densistriatus,* which, however, has a comparatively broad smooth band on the rounded venter. (See Burckhardt, 1912, p. 191, Pl. XLV, figs. 1–3.)

SUMMARY

The results of the writer's study of the ammonites of the Malone area are briefly summarized in the following paragraphs.

The form previously designated by Cragin as *Oppelia* (?) *fallax* Castillo and Aguilera was found to differ significantly from the Mexican species. It appears, moreover, that the Malone form is better classified with *Haploceras* than with *Oppelia,* a suggestion originally made by Spath (Kitchin, 1926, pp. 457–458). Accordingly, the Malone form has been assigned to a new species of *Haploceras* named for Dr. Cragin.

Haploceras cragini exhibits more variation in whorl-section and umbilication than any other Malone species. Included in the writer's collection are forms constituting a gradational series from relatively robust to markedly compressed forms, all of which possess essentially the same suture patterns and external markings. The species is confined to the lower division of the Malone formation.

The writer has followed Burckhardt's suggestion in referring the species designated by Cragin as *Perisphinctes schucherti* and *P. clarki* to the genus *Idoceras*. Both forms are closely related to Kimmeridgian species described by Burckhardt from San Pedro del Gallo.

The forms previously designated as *Oleostephanus malonianus* Cragin, *Perisphinctes potosinus* Castillo and Aguilera, and *P. felixi* Castillo and Aguilera have been found to represent successive stages in development of a single species of *Lithacoceras*, here designated as *L. malonianum* (Cragin). Previously, Spath had recognized that "*Oleostephanus*" *malonianus* should be reassigned to *Lithacoceras* (Kitchin, 1926, pp. 457–458). *L. malonianum*, which is restricted to the lower division of the Malone formation, is closely related to, if not actually identical with the Kimmeridgian species designated by Burckhardt (1906, pp. 24–25) as *Perisphinctes melachlani.*

The species designated by Cragin as *Perisphinctes aguilerai* is confined to the upper division of the Malone formation. As Uhlig has noted (1907, p. 286), this form belongs to the group of *P. richteri*, "a widely distributed east-Indian and European group of Tithonian age." This group had been previously assigned to the genus *Kossmatia* by Uhlig (1903). The writer has discovered no features in his specimens to prohibit assignment of the Malone species to Uhlig's genus.

Associated with *Kossmatia aguilerai* (Cragin) is *K. zacatecana* Burckhardt, which has not been previously reported from the Malone area. *K. zacatecana* is characteristic of the upper Portlandian (Tithonian) of Mazapil (Burckhardt, 1912, pp. 136–138).

Of particular stratigraphical importance was the discovery of two forms previously described from the Kimmeridgian of San Pedro sel Gallo. These are *Aspidoceras laevigatum* Burckhardt and *Neobrites nodocostatus* Burckhardt, both locally restricted to the lower division of the Malone formation.

Ammonites are rare in the Torcer formation, and where found were confined to the basal sandstone and conglomerate. Most of the specimens are too fragmentary and ill-preserved for even generic identification. A single specimen of *Neocomites* cf. *indicus* Uhlig was, however, collected near V Canyon. The Indian species is from the Valanginian Cretaceous. Species of *Neocomites* have been described from the Berriasian (infra-Valanginian) of Mexico by Burckhardt (1912, p. 227). The stratigraphical evidence supplied by *Neocomites*, it should be noted, is in accordance with that of the associated foraminifera.

In addition to the species noted above, three new species of *Physodoceras* and one of *Lithacoceras* were discovered in the lower division of the Malone formation.

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